DOI: https://doi.org/10.53350/pjmhs22163239

**ORIGINAL ARTICLE**

# Diagnostic Value of Diffusion-weighted Magnetic Resonance (MR) Imaging and MRS in Assessment of Malignant Brain Lesions

SAMMER SAEED[1], SAIMA AMEER[2], HAROON SAEED[3], UZMA HABIB[4], NADIA HANIF[5], SMEERA SIDDIQUE[6]
*[1]FCPS Resident in Diagnostic Radiology, PGMI/ AMC/LGH, Lahore*
*[2]Head of Radiology Department, PGMI/ AMC/LGH, Lahore*
*[3]Assistant Professor Radiology, PGMI / AMC/ LGH, Lahore*
*[4]Assistant Professor Radiology, PGMI / AMC/ LGH, Lahore*
*[5]Assistant Professor Radiology, PGMI / AMC / LGH, Lahore*
*[6]Assistant Professor Radiology, PGMI / AMC/ LGH, Lahore.*
*Corresponding author: Dr Sammer Saeed, Email: Sammersaeed2405@gmail.com*

## ABSTRACT
**Background:** The purpose of the study is to evaluate the diagnostic value of DWI and MRS in assessment of the malignant brain lesions.
**Materials and methods:** The study was conducted in Department of Diagnostic Radiology from March 2021, to December 2021 in Lahore General Hospital. Sample size selected was 50 patients referred to the Department of Diagnostic Radiology for their suspected brain lesion assessments. The patients were evaluated by the DWI magnetic resonance imaging and MRS. Classifications of lesions were benign and malignant on the basis of radiological findings. The data was compared with the histopathological results as a gold standard.
**Results:** The malignant lesions from benign lesions were differentiated with DWI images and ADC mapping. Lower ADC values with restricted diffusion was considered malignant and higher ADC value with no restricted diffusion was considered benign. DWI images findings had the 77% sensitivity and 75% specificity. Cho/Cr, Cho/ NAA ratios has highest sensitivity and specificity at short TE (96%,86%)
**Conclusion:** DWI and MRS are helpful noninvasive techniques in detecting the malignant brain lesions and can help to avoid unnecessary biopsy in the patients suspecting brain lesions.
**Keywords:** Brain lesion, Diffusion weighted image, Malignant, Benign, MRS

## INTRODUCTION
Disease or injury in the brain is called brain lesion. It sounds simple but the complications are involved in the lesions it can range from small lesions to large lesions from benign lesions to life threating lesions. Causes of brain lesions can be infection, injury, exposure to chemicals, immune system problem and many unknown reasons. Symptoms of brain lesions depends upon the location and size of the lesion and may vary from patients to patients but the general symptoms may include

- Stiffness or neck pain
- Headache
- Lack of appetite, vomiting and nausea
- Eye pain or change in vison
- Changes in concentration and mental ability
- Confusion or loss of memory
- Fever
- Seizures
- Moving difficulty

Common brain lesions are

- Arteriovenous malformations (AVMs)
- Abscess
- Cerebral infarction
- Cerebral palsy
- Multiple sclerosis
- Brain tumors

The origin of brain tumor is from neural elements or it may be due to distant cancer spread. Half of the intracranial neoplasm starts from CNS tissues and remaining may be due to metastatic lesions. There are different diagnostic techniques available to identify the brain lesions which may include MRI, DWI, MRP and MRS. Sensitivity and specificity is high when combinations of MRI techniques are used to differentiate the benign lesions from malignant lesions. DWI magnetic resonance imaging is a noninvasive diagnostic options used for prognosis and treatment plan for grading the tumor (Pierce T et al ,2014). For identification of intracranial mass lesions MRI is considered primary and initial screening tool. (Surov A,2016)

Applications of Diffusion weighted images have been enhanced in assessment of solid masses in brain and considered helpful in distinguishing malignant lesions from benign (Vandendries C et al, 2014). Brownian motion of water is identified under DWI MR images hence representing the biological features of tissues and ADC (apparent diffusion coefficient). ADC helps to quantify the Brownian motion. (Prager AJ, et al, 2015). The ADC value of DW-MRI is quantified by reduction in signal intensity which is calculated from DW-MRI series at different b value. ADC values and DWI images add value to the information identified for grading and differentiating the brain tumors (Brandao LA et al, 2013) Sensitivity and specificity of DWI in detecting the brain tumor is accepted widely.

MRS is also noninvasive and advance modality of MRI technique and is used to differentiate the brain lesions. It is widely used in grading and quantifying the brain tumors. Specificity and sensitivity of MRS is high and if DWI and MRS both used in combination it can generate the 100% sensitivity and specificity keeping histopathology as a gold standard (A. Jesrani et al, 2019).

The present study has helped to identify the diagnostic value of DWI and MRS in assessment of malignant brain lesions

## MATERIAL AND METHODS
The Retrospective study was conducted in the Department of Diagnostic Radiology from March 2021, to December 2021.Sample size was 50 patients referred for assessment of brain lesions by using DWI-MR images and MRS. Among the total sample 24 were female patients and 26 were male patients with age range of 18-75 years. Convenient sampling technique was used.

Machine used for MRI imaging was Siemens Avanto 1.5 Tesla Machine and brain coils also used. T1 weighted image and T2 weighted images were used to illustrate the difference in the relaxation time of tissues. Planes used for weighted images were Sagittal, Coronal and Axial

**Diffusion weighted Images:** Axial plane EPI (echo planner imaging) sequence was used for DWI-ADC mapping with b factor was 0, 500 ,1000 s/mm², FOV (field of view) 23 cm, 256 x 77 matrix. ADC mapping was performed with these specifications using x-y-z planes. ADC mapping was calculated by finding region of interest from lesion, contralateral region, for every lesion three ROI measurements were recorded from posterior, anterior and Para median sites. Average of three ROI was calculated and considered ADC value. ROI size used was; 5-7 mm². Malignant lesions showed lower ADC value and restricted diffusion.

**MR Spectroscopy:** MR spectroscopy was performed by using PRESS (point resolved spectroscopy with VOI (volume of interest)

1 x 1 x 0.5 cm3 and multivoxel spectroscopy with standard voxel sizes and around the VOI presaturation band was used. Depending upon the size of lesion and type of lesion 5-10 cm3 approximately multivoxel imaging of tumor area was harbored with standard voxels. Position was made with voxel for lesion area avoiding skull or scalp base contamination, brain parenchyma appearing normal and areas of cysts. In order to optimize homogeneity of field, automatic shimming of x,y,z linear channel, water suspension pulses and water resonance was optimized for water saturation consistency.

From MRI results nature of lesion, pattern of lesions, necrosis, heterogeneity and perilesional edema were expressed. Statistical analysis was performed by using SPSS version 15. For differentiating the benign lesion from malignant lesion ROC (receiver operating characteristics curve cut off values was obtained for ADC ratios. P<0.05 was considered significant

## RESULTS

From the results mean age group of the participants was ±41.4 and the mean duration of the sign and symptoms were found 5.62 ± 2.54 months. DWI images and ADC mapping evaluated that the lower ADC values and restricted diffusion as compared to normal brain parenchyma was considered malignant, ADC values in malignant cases were between 0.32-0.62×10-3 s/mm². The lesions with high ADC value, isointense on cerebral fluid and have no restricted diffusion than the normal brain parenchyma was considered benign ADC values in benign cases were between 0.36-3.21×10-3 s/mm². From DWI results 18 cases were reported as malignant and 32 were benign. When compared with the histopathological results true positive malignant cases were 15 and from benign lesions 4 cases were also found malignant. From the DWI and histopathology results sensitivity calculated was 77 % and specificity recorded was 75 %.

Table DWI results

| Indicators | Cases |
|---|---|
| Male | 26 |
| Female | 24 |
| Malignant lesion | 18 |
| Benign Lesion | 32 |
| Age Range | 20-75 years |
| Mean age | ±41.4 years |
| Sign and symptom mean duration | 5.62 ± 2.54 months |
| Sensitivity | 77% |
| Specificity | 75% |
| Malignant ADC Values (cut of values) | 0.32-0.62×10-3 s/mm². |
| Benign ADC values (cut of values) | 0.36-3.21×10-3 s/mm² |

Table Results of the MRS

| Indicators(cut off values) | Cases |
|---|---|
| Malignant cases | 19 |
| Benign cases | 31 |
| Cho/NAA ratio(Long TE) | 1.394 |
| Cho/Cr ratio(Long TE) | 1.294 |
| NAA/Cr ratio( Short TE) | 3.214 |
| Cho/NAA ratio(Short TE) | 1.345 |
| Cho/Cr ratios ratio(Short TE) | 1.49 |
| Sensitivity | 98% |
| Specificity | 86% |

The measurements obtained from long TE and Short TE by MRS was compared with the normal brain parenchyma measurement and they were divided into malignant and benign according to the predominant metabolite peak and metabolite ratio. In the malignant cases Cho/NAA ratio in short TE was 1.41-2.16 and in long TE 1.43-2.29. At short TE Cho/Cr ratio was 0.37-3.32 and at long TE 1.78-5.22. At short TE NAA/Cr ratio was .1-3.54 and at long TE 1.66-3.97. The lesions were considered benign when Cho is not increasing, NAA depression is not observed and predominant metabolite NAA is observed. The lesions which were considered malignant have NAA depression, increased Cho/NAA ratio and Cho/Cr ratio. By MRS 19 lesions were described as malignant while 31 were described as benign. And true positive were 18 malignant lesions and 2 were found malignant from benign lesions in histopathological results. MRS had 98% sensitivity and 86% specificity.

## DISCUSSIONS

Standard imaging technique in the brain tumor diagnosis is considered MRI imaging. Conventional method of MRI parameters observed in malignant lesions were mass effect, enhancement, heterogeneity and signal intensity but theses parameters were not representing accurate results. For accuracy of diagnosis advance techniques of MRI like MRP, MRS and DWI were recommended. These techniques are metabolic, functional cellular and hemodynamic methods for detection of brain lesions. These techniques are used for neoplastic lesions grading and for treatment planning.

DWI technique is used for the assessment of tumors , differentiation and grading ,it is also helpful in the ischemic stroke diagnosis (Razek AA et al, 2014).Many researchers found that there is an inverse correlations between the DWI images , tumor cellularity and ADC calculated (Sepahdari AR et al, 2014).Higher tumor grade marker showed lower ADC values and higher ADC values showed lower tumor grades(Nooman AD, et al, 2016).From our study also lower ADC values were observed in malignant lesions and high ADC values were recorded in benign lesions.

MRS is also noninvasive technique and help in sharing metabolic information for diagnosis and surgical treatment (Brandao LA,2013). This technique helps in identification of tumor type and grade. Lipid and lactate peaks were found consistent in aggressive lesions hence illustrating cellular necrosis and anaerobic metabolism increase (Seeger A et al,2013). Cho/NAA ratio were found higher in malignant group as compared to benign group (1.87 in malignant and 1.062-.083 in benign). A study conducted by Fatima, et al 2014 and Naser et al 2016 has also confirmed that ratios Cho/NAA and Cho/Cr are higher in high grade tumors as compared to the low grade tumor

## CONCLUSION

DWI and MRS scans are a noninvasive option to determine the brain lesion. When both techniques used in combination for identifications of brain lesions they have diagnostic accuracy of 99%. Sensitivity and specificity is high when used in combination. Histopathology is gold standard for verifying the diagnostic accuracy of DWI and MRS imaging.

## REFERENCES


1. A. Jesrani, R. Ajmal, M. Asad, and S. N. Zehra, "Diagnostic accuracy of magnetic resonance spectroscopy in differentiating neoplastic from non-neoplastic enhancing brain lesions taking histopathology as gold standard, experience at Liaquat National Hospital, Karachi, Pakistan," *Acta Scientific Cancer Biology*, vol. 3, no. 10, pp. 3–8, 2019.View at: Google Scholar
2. Brandao LA, Shiroishi MS, Law M. *Magn Reson* ,Brain tumors: a multimodality approach with diffusion-weighted imaging, diffusion tensor imaging, magnetic resonance spectoscopy, dynamic susceptibility contrast and dynamic contrast-enhanced magnetic resonance imaging. *Imaging Clin N Am.* 2013;21:199–239. [PubMed] [Google Scholar] CAS Article Google Scholar
3. de Fatima Vasco Aragao M, Law M, Batista de Almeida D, Fatterpekar G, Delman B, Bader AS et al (2014) Comparison of perfusion, diffusion, and MR spectroscopy between low-grade enhancing pilocytic astrocytomas and high-grade astrocytomas. AJNR Am J Neuroradiol. 35(8):1495 –1502 23.
4. de Fatima Vasco Aragao M, Law M, Batista de Almeida D, Fatterpekar G, Delman B, Bader AS et al (2014) Comparison of perfusion, diffusion, and MR spectroscopy between low-grade enhancing pilocytic astrocytomas and high-grade astrocytomas. AJNR Am J Neuroradiol. 35(8):1495 –1502 23.
5. Naser RKA, Hassan AAK, Shabana AM, Omar NN (2016) Role of magnetic resonance spectroscopy in grading of primary brain tumors. Egypt J Radiol Nucl Med. 47(2):577 –584

6. Nooman AD, Mohamed NA, Mohamed AR et al (2016) Role of magnetic resonance spectroscopy &diffusion weighted imaging in differentiation of supratentorial brain tumors. The Egyptian J Radiol Nucl Med 47:1037–1042
7. Pierce T, Kranz PG, Roth C, Leong D, Wei P, Provenzale JM ,Use of apparent diffusion coefficient values for diagnosis of pediatric posterior fossa tumors.. *Neuroradiol J.* 2014;27:233–244. [PMC free article] [PubMed] [Google Scholar]
8. Prager AJ, Martinez N, Beal K, Omuro A, Zhang Z, Young RJ Diffusion and perfusion MRI to differentiate treatment-related changes including pseudoprogression from recurrent tumors in high-grade gliomas with histopathologic evidence.. *AJNR Am J Neuroradiol.* 2015;36:877–885. [PMC free article] [PubMed] [Google Scholar]
9. Razek AA, Abdalla A, Ezzat A et al (2014) Minimal hepatic encephalopathy in children with liver cirrhosis: diffusion-weighted MR imaging and proton MR spectroscopy of the brain. Neuroradiology 56:885–891
10. Seeger A, Braun C, Skardelly M, Paulsen F, Schittenhelm J, Ernemann U, Bisdas S. *Acad Radiol. 2013* Comparison of three different MR perfusion techniques and MR spectroscopy for multiparametric assessment in distinguishing recurrent high-grade gliomas from stable disease. 2013;20:1557–1565. [PubMed] [Google Scholar]
11. Sepahdari AR, Politi LS, Aakalu VK et al (2014) Diffusion-weighted imaging of orbital masses: multi-institutional data support a 2-ADC threshold model to categorize lesions as benign, malignant, or indeterminate. AJNR Am J Neuroradiol 35:170–175
12. Surov A, Ginat DT, Sanverdi E, Lim CT, Hakyemez B, Yogi A, et al. Use of diffusion weighted imaging in differentiating between malignant and benign meningiomas. A Multicenter Analysis. *World Neurosurg.* 2016;88:598–602. [PubMed] [Google Scholar]
13. Vandendries C, Ducreux D, Lacroix C, Ducot B, Saliou G. *J Magn Reson Imaging.* Statistical analysis of multi-b factor diffusion weighted images can help distinguish between vasojenic and tumor-infiltrated edema. 2014;40:622–629. [PubMed] [Google Scholar]